13.—Foraminiferal Evidence for the Paleocene Age of the King's Park Shale (Perth Basin, Western Australia)

By Brian McGowran*

Manuscript received—16th June, 1964

Several species of foraminifera in the King's Park Shale are found also in other Australian faunas dated firmly as Paleocene. Some, including *Globorotalia chapmani* Parr, *Globorotalia pseudomenardii* Bolli, *Lamarckina rugulosa* Plummer, are Paleocene index fossils. There is no significant evidence for dating the King's Park Shale as Eocene.

Introduction

In 1938 the late W. J. Parr described a foraminiferal fauna found in samples from two bores in King's Park, Perth, Western Australia. Parr concluded that the fauna was Eocene, and probably Upper Eocene, in age. Later he prepared several more samples, mainly from the nearby Langley Park bore, which were richer in both numbers and age-diagnostic species than the original material. However, nothing further had been published on the fauna when Parr died in 1949. The fauna has been studied subsequently but no worker has made a serious attempt to revise Parr's conclusions in the light of new, richer material or the recent major advances in our knowledge of Lower Tertiary biostratigraphy. Nevertheless this assemblage and its dating have been relied upon quite heavily, particularly by Crespin (see refs.), in studies of other Lower Tertiary faunas in Australia.

The material prepared by Parr has been used by the writer for comparative purposes in his studies on the Australian Paleocene (unpubl. thesis, 1962). This paper presents evidence for redating the King's Park Shale as Paleocene. Reference is made continually to the Paleocene faunas of the Carnarvon Basin, Western Australia, and the Otway Basin, Victoria. Papers in preparation on these faunas will discuss and figure most of the species invoked here, as well as some of the repercussions in species identification arising from the age revision of the King's Park Shale. However, *Globorotalia chapmani* Parr is discussed and figured below.

Material.—King's Park Bore No. 1: 10 samples between 780 ft. and 120 ft.

King's Park Bore No. 2: 8 samples between 728 ft. and 150 ft.

Langley Park Bore: 7 samples between 975 ft. and 208 ft.

Claremont Bore: 1 sample, 300-350 ft.

Types of 17 species erected by Parr and other specimens.

Specimens separated by M. F. Glaessner from core at 1505 ft., South Perth Bore (see Glaessner 1956).

For localities, see Coleman, 1952, text-fig. 1.

* University of Adelaide, South Australia.

Acknowledgements

The Parr material was made available and permission to write this paper was granted by Prof. R. T. Prider and staff, Dept. of Geology, University of Western Australia. This cooperation is acknowledged most gratefully. Thanks are due also to Prof. M. F. Glaessner (Dept. of Geology, University of Adelaide), who read and criticized the manuscript, and to Mr. B. E. Balme (Dept. of Geology, Univ. of Western Australia) for his comments and for presenting the paper.

Stratigraphic Relationships

The following notes are based on McWhae *et al.* (1958) and references given by these authors.

The sedimentary sequence under consideration, part of the thick infill of the Perth Basin, has been named the King's Park Shale by Fairbridge (in Coleman, 1952). The formation is known only from bores in the Perth area, where it varies, in drilled thickness, from 660 feet in the King's Park no. 1 bore to more than 1000 feet in the South Perth bore, less than two miles away. The sequence consists of grey calcareous shales and mudstones, pyritic in part. The King's Park Shale overlies the South Perth Formation (uppermost Jurassic to Lower Aptian) and the Osborne Formation (?Aptian, Albian to Cenomanian); and it is succeeded by Quaternary limestones and clays.

Previous Studies

In arriving at his conclusions, Parr (1938, p. 69, 90) relied largely on Cushman's studies on the North American Eocene and Oligocene faunas. Cushman published on the Paleocene of North America largely between 1940 and 1949; also, important studies on Paleocene faunas by Brotzen (1948) and others were not available to Parr. Added to these points in Parr's defence are several others: the Midway of Texas (Plummer 1927) was thought of as Lower Eocene instead of Dano-Paleocene; the biostratigraphic value of planktonics was becoming appreciated only then (e.g., Glaessner 1937a); and the Upper Eocene microfaunas of southern Australia were not yet known. Indeed, very little has been published on the Paleocene even to the present day. Consequently it is hardly surprising that Parr's conclusions can be revised by new approaches to the problem.

Concerning the King's Park fauna, Crespin (1950, p. 424) stated that " . . . there is no indication with what part of the Eocene it can be correlated". Subsequently, however (Crespin

1954, 1956a,b, 1958, Raggatt and Crespin 1955), Crespin has emphasized the similarity of various faunas mostly in South Australia and Victoria to the fauna described by Parr; and she has accepted the Upper Eocene age of the latter. On the other hand, Crespin (1956a) has noted the similarity in some respects of the King's Park fauna to the Paleocene faunas of the Carnarvon Basin (see also below).

Coleman (1952) studied the foraminifera from six bores in the Perth metropolitan area. He noted (p. 37) that "the faunal assemblage as a whole is unlike that of any other region in Australia"; but he did not discuss its age, concentrating instead on bore-to-bore correlation. In a footnote (p. 42), however, Coleman records a suggestion by Crespin that the King's Park assemblages are closely similar to the faunas in the Swedish Paleocene (Brotzen 1948), and that "it is probable then that at least part of the fauna of the Perth Basin . . . is of Paleocene age". Glaessner (1956) and Belford (unpublished report to Bureau Mineral Resources, Canberra; referred to by Cookson and Eisenack, 1961) found King's Park Shale species in samples from the South Perth and Rottnest Island bores respectively. Both workers dated their samples on the basis of Parr's conclusions.

Churchill (1960) refers in passing to the Paleocene age of the King's Park Shale at a relatively high level in the subsurface (Narrows bore 164 ft.). Churchill's evidence presumably is palynological but to the writer's knowledge this evidence has not been published.

The most recent discussion of the age of these rocks is provided by Cookson and Eisenack (1961). In a study of microplankton and pollen from the Rottnest Island bore to the west of Perth, they state (p. 47): "Although the evidence . . . is inconclusive, it shows that the Rottnest deposits are Eocene and clearly younger than the Paleocene to Lower Eocene Pebble Point Formation of Victoria . . . The Upper Eocene age suggested by Belford for the Rottnest Bore deposits on the basis of foraminifera is not incompatible with their pollen and microplankton content, but it is equally possible that they may have been older than this". The material studied by Cookson and Eisenack came from between 1480 and 1595 feet; there is no reason to doubt the continuity of this deposit with the King's Park Shale on the nearby mainland.

It is clear that several workers regard Parr's original age determination as being too young. Mr. B. E. Balme (Dept. Geol., Univ. W. Aust.) has kindly informed the writer (pers. comm.) that a Paleocene age makes interpretation of the palynological evidence very much easier.

Correlation and Age of the King's Park Shale

Note on comparison with Upper Eocene faunas.—Several species occurring in the fauna are found also in various firmly dated Upper Eocene sediments. However, an inspection of several Upper Eocene faunas, particularly those from the Brown's Creek Clays in western Victoria, has shown that the resemblances are less striking than Crespin and others have implied. In the absence of monographic studies, the true faunal relationships cannot be fully demonstrated. But we may note a few examples of alleged occurrences of King's Park species in the Upper Eocene (e.g. Carter 1958) which are based on misidentification (the Eocene species will be discussed elsewhere):

Bolivinopsis crespinae Parr.
Alabamina westraliensis (Parr).
Chiloguembelina rugosa (Parr).

More significantly, several important Upper Eocene species (see Parr 1947, Carter 1958, Glaessner and Wade 1959, Ludbrook 1963) are not found in the King's Park Shale. Among others in this category, there are:

Globigerapsis index (Finlay).
Pseudohastigerina micra (Cole).
Hantkenina alabamensis compressa Parr.
Asterigerina adelaidensis (Howchin).
Carpentaria hamiltonensis Glaessner & Wade.
Maslinella chapmani Glaessner & Wade.
Lamarckina airensis Carter.

Comparison of King's Park Shale with Australian Paleocene faunas.—The King's Park Shale shows considerable overall faunal resemblance to the Carnarvon Basin Paleocene. Parr (1938) identified nearly 70 species in the King's Park Shale; Coleman (1952) has found more than 90. Of about 100 species found so far by the writer (unpubl. thesis) in the Boongerooda Greensand (McWhae *et al.* 1958, and refs.), more than 50 have been identified in the King's Park Shale material at hand.

About 100 species have been identified also in two Paleocene faunas from the Wangerrip Group, Otway Basin, western Victoria (Baker 1953, and refs.). Again, more than 50 occur also in the King's Park Shale. This similarity is greater than with the Boongerooda Greensand because the two Victorian faunas, from the Pebble Point Formation and the Rivernook Member of the Dilwyn Clay respectively (Baker, 1953), are mutually quite distinct.

Correlation of the King's Park Shale with the sequence in western Victoria is based largely on the mutual occurrence of the following benthonic species. That some of them are very rare is of little importance; it is their presence that matters, because not one is known authentically from the Australian Upper Eocene.

Vaginulina longiforma (Plummer).
Citharina subplumoides (Parr).
Angulogerina sp.
"*Bolivinopsis crespinae Parr*" (believed to be *Spirobolivina emmendorferi* (Jennings)).
Alabamina westraliensis (Parr) (*A. wilcoxensis* Toulmin is considered a junior synonym).
Ceratobulimina westraliensis Parr.
Lamarckina rugulosa Plummer.
Lamarckina aff. *L. naheolensis* Cushman & Todd
Epistominoides aff. *E. midwayensis* Plummer.
Anomalinoides westraliensis (Parr) (*Cibicides danica* Brotzen is considered a junior synonym).

As well as providing a firm basis for correlation within the Australian region, this list of species suggests most strongly that the King's Park Shale is Paleocene in age. With the exception of *Angulogerina* sp., all these species or closely related forms are found in the Paleocene of the North American Gulf Coast (Olsson 1960, Cushman 1951 and refs.). Similarly, several occur in the Paleocene of Scandinavia (Brotzen 1948) and Poland (Brotzen and Pozaryska 1957, 1961). *Lamarckina rugulosa* perhaps is the most significant Paleocene index fossil in the above list (see also Pozaryski and Pozaryska 1960). Only a few specimens have been found in the King's Park Shale, but *L. rugulosa* is common in the Rivernook Member of the Dilwyn Clay.

Planktonic species and their significance.—The King's Park Shale is less rich in plankonics than the Boongerooda Greensand, which is "Tethyan" in its species diversity and large numbers of specimens. Nevertheless the planktonics are the most conclusive evidence for dating the formation. The following elements have been identified:

- *Globorotalia chapmani* Parr (60 specimens).
- *Globorotalia pseudomenardii* Bolli (2 specimens).
- *Acarinina mckannai* (White) and related forms (relatively common).
- *Globigerina linaperta* Finlay species group.
- *Chiloguembelina crinita* (Glaessner) (20 specimens).
- *Chiloguembelina trinitatensis* (Cushman & Renz) (2 specimens).
- *Zeauvigerina aegyptiaca* Said & Kenawy (3 specimens).

In 1957 Bolli published a detailed zonation of the Lower Tertiary Lizard Springs Formation of Trinidad, with five zones spanning the Dano-Paleocene interval. This zone sequence has been extended to other sections in Europe and the Americas, unaltered or in somewhat modified form, and the writer has used it in the Carnarvon Basin Paleocene. The zone sequence for the Dano-Paleocene, as modified by Berggren (1964), is as follows:

Globorotalia velascoensis Zone	*Globorotalia velascoensis* subzone.
	Globorotalia pseudomenardii subzone.
Globorotalia pusilla pusilla—Globorotalia angulata Zone.	
Globorotalia uncinata Zone.	
Globigerina daubjergensis—Globorotalia trinidadensis Zone.	

For the purpose of this discussion, the *G. velascoensis* Zone is equated with Upper Paleocene.

It has become clear over the past few years that *Globorotalia chapmani*, masquerading as "*Globorotalia elongata* Glaessner", etc. (see p. 85), is restricted in its total range to the upper part of the Paleocene. The only significant occurrence of *G. chapmani* in apparently younger sediments was in the Nanafalia Formation at the base of the Wilcox in Alabama, dated as basal Eocene by Loeblich and Tappan (1957). The Nanafalia, however, is Paleocene, in the *G. Pseudomenardii* subzone (Bramlette and Sullivan 1961, Gartner and Hay 1962, Berggren 1964). *Globorotalia chapmani* first appears in the *G. pusilla pusilla-G. angulata* Zone, and occurs most commonly in association with *G. pseudomenardii*, as in the Boongerooda Greensand. There are records from the *G. velascoensis* subzone (e.g. Hay 1960) though the species is not found in the highest known Paleocene in the Carnarvon Basin. Thus its appearance at depth in the King's Park Shale (South Perth 1505 ft., Langley Park 951 ft.) and its range up to and including the highest samples available (King's Park 120 ft., King's Park No. 2 150 ft., Langley Park 208-224 ft.) is decisive for age and correlation.

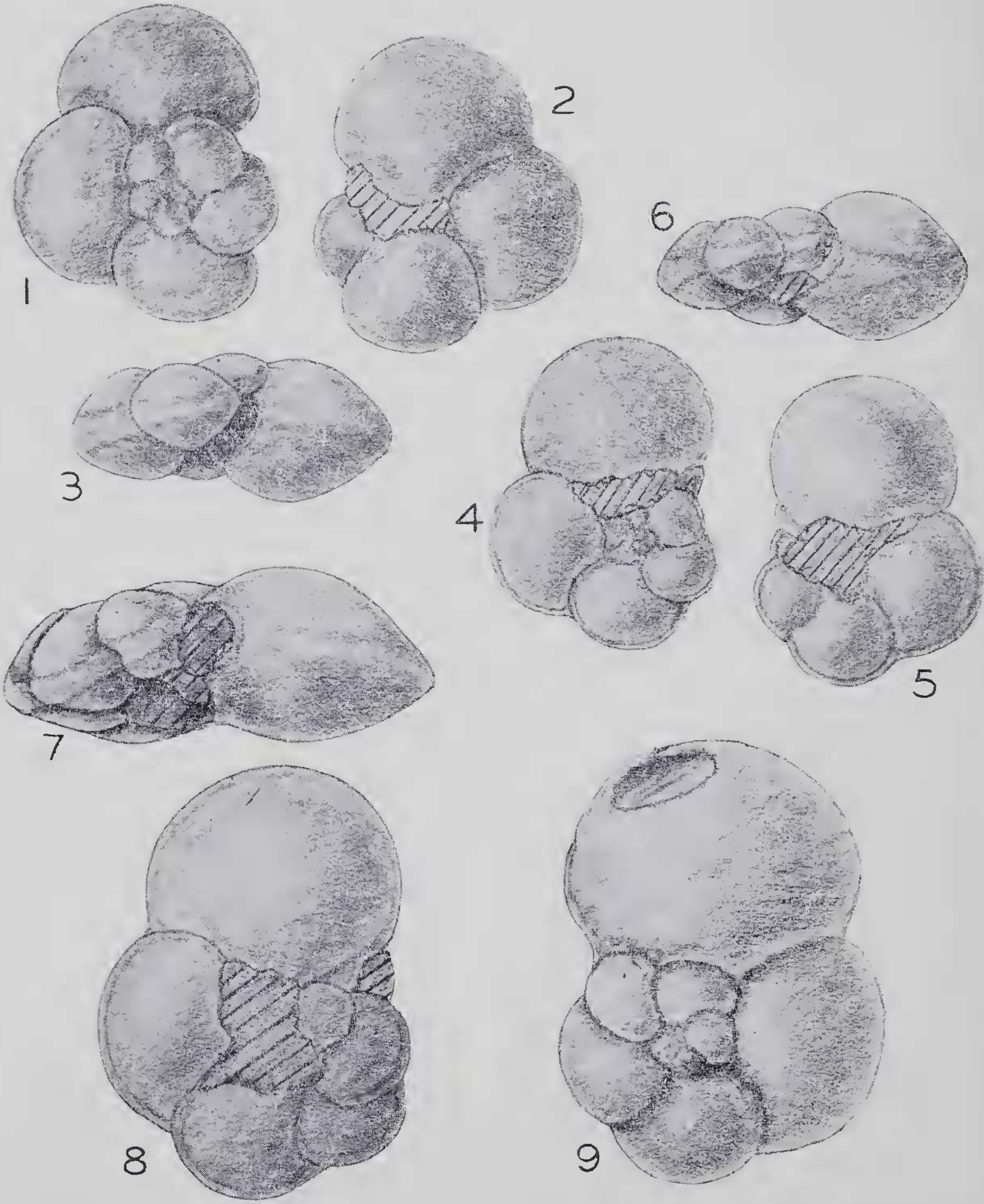
The occurrence even of two specimens of *Globorotalia pseudomenardii* (Langley Park 400 ft., 208-224 ft.) also is significant. Gartner and Hay (1962) have emphasized the wide distribution and restricted range of *G. pseudomendardii.* Whether the species always is restricted to the *G. pseudomenardii* zone as defined by Bolli (1957, see also Bolli and Cita 1960, Hay 1960) is not quite clear. It seems probable that like *G. chapmani*, it persisted with restricted numbers and distribution into the *G. velascoensis* subzone. While common in the Boongerooda Greensand and its deeper water equivalents in the Carnarvon Basin, *G. pseudomenardii* is represented in the highest Paleocene only by a few small specimens.

A Paleocene age is supported by the remaining planktonic elements of the King's Park Shale fauna. These species occur in the Boongerooda Greensand together with additional species not found in the King's Park Shale. The variable species group referred tentatively to *Acarinina mckannai* (White) (see von Hillebrandt, 1962, Gohrbrandt, 1963, and references therein) includes also morphotypes which have been identified by some workers under other names; but all are characterized by reniform chambers in a low to (particularly) high spired arrangement. Large samples of well preserved material are needed to study this variation adequately. The presence of this group suggests the *G. velascoensis* Zone (*s. l.*) equivalents without definitely excluding Lower Eocene. More locally, however, the group is restricted in the Carnarvon Basin like *G. chapmani*, being abundant in the *G. pseudomenardii* subzone but not occurring higher. The Middle Eocene index species *Globigerina orbiformis* Cole (= *Porticulosphaera mexicana* (Cushman)), as identified and figured by Parr (1938), belongs to *A. mckannai.*

Gümbelina venezuelana Nuttall var. *rugosa* Parr 1938 is a junior synonym of *Gümbelina crinita* Glaessner 1937. The occurrence of *Chiloguembelina crinita, Ch. trinitatensis* Cushman & Renz and *Zeauvigerina aegyptiaca* Said & Kenawy support the evidence cited above still further. Beckman (1957) has studied the distribution of *Chiloguembelina* etc. in the Trinidad Lower Tertiary, with reference to Bolli's zone sequence. He has found that the three species listed are restricted to the Upper Paleocene. Other records (Loeblich and Tappan 1957, Said and Kerdany 1961) support this.

General Discussion and Conclusions

An analysis of the planktonic foraminiferal fauna, particularly the occurrence throughout of *Globorotalia chapmani*, has shown that the King's Park Shale is Paleocene in age. The same evidence, however, is not good enough to indicate positively the interval spanned in terms of the biostratigraphic sequence currently used. But it is likely that most of the formation was restricted in time of deposition to the *Globorotalia pseudomenardii* subzone. The fauna, particularly the presence of the *Acarinina mckannai* species group throughout, suggests the absence of the *G. pusilla pusilla-G. angulata* Zone. And apart from the long-ranging *Globigerina linaperta* species group, the King's



Globorotalia chapmani Parr. 1, 4, 8, 9: spiral views; 3, 6, 7: edge views; 2, 5: umbilical view. Adherent matrix indicated by diagonal ruling. 1-3.—(52643) Claremont Bore, 300-350 ft. 4-6.—(52644) Langley Park Bore, 400 ft. 7-8.—(52645) Langley Park Bore, 951 ft. 9.—(18897) King's Park Bore No. 1, 755 ft. (Subsidiary specimen figured by Parr, 1938, pl. 3, fig. 8; here refigured). Registered numbers: Geology Department, University of Western Australia. All specimens from Parr Collection therein. All figs. X132.

Park species are not found in *G. velascoensis* subzone equivalents in the Carnarvon Basin, but they are all present (except perhaps *Ch. trinitatensis*) in the Boongerooda Greensand and other *G. pseudomenardii* subzone equivalents.

The King's Park Shale can be correlated with the Otway Basin Paleocene in Victoria on the basis of several mutually occurring benthonic species which have been found also in the Paleocene of Europe and North America. These species do not have the biostratigraphic precision of the planktonics at present, but the fauna as a whole decidedly is Paleocene in general aspect. Of course, some species extend into the Eocene. The only definite Lower Eocene foraminiferal faunas known at present in Australia occur in the Carnarvon Basin, where planktonic index species have been found by Glaessner (McWhae *et al.* 1958) and the writer. The King's Park Shale contains no species which could suggest a definite correlation with these faunas or with the more widespread and sometimes rich Middle to Upper Eocene faunas. All the species in common have unknown but long stratigraphic ranges. Hence all the negative evidence available, that is, the absence of Eocene planktonic and significant benthonic species, supports the positive evidence embodied in the presence of Paleocene planktonic and benthonic species in the King's Park Shale.

We have discussed the Paleocene only with reference to its zonal subdivision. The use of stage names has been avoided; this subject is in a state of flux and is outside the scope of the present paper. It is sufficient to date the King's Park Shale as Upper Paleocene, definitely younger than Danian and Lower Paleocene.

These conclusions are more definite than those reached by Cookson and Eisenack (1961). Cookson and Eisenack compared the Rottnest bore microplankton and microflora with Cookson's "Microflora C" of the Victorian Lower Tertiary (Cookson 1954), particularly by the presence of the pollen species *Proteacidites pachypolus* Cookson and Pike. "Microflora C" is of indefinite Lower Tertiary age, though definitely younger than the Pebble Point Formation in Victoria. The Pebble Point Formation has been regarded as Lower Eocene with Paleocene affinities by Baker (1953 and refs.) who relied on somewhat inconclusive studies of its molluscan and foraminiferal content by Teichert, Singleton, Glaessner and Parr; and Cookson and Eisenack have assumed a Paleocene to Lower Eocene age on this basis, not on the basis of its microflora or microplankton content. A study of the Pebble Point foraminifera by the present writer has suggested a correlation with the *Globorotalia pusilla pusilla-G. angulata* Zone, slightly older than the *Globorotalia pseudomenardii* subzone. A Middle Paleocene age is supported also by the correlating of the Rivernook Member of the overlying Dilwyn Clay with the *Globorotalia velascoensis* subzone or uppermost *G. pseudomenardii* subzone, that is, Upper Paleocene. Thus, it appears on biostratigraphic evidence that "Microflora C" in part is of Upper Paleocene age. On the other hand, the interval under consideration in the Rottnest Is. bore (1480 to 1595 feet) may be younger than the King's Park Shale as developed beneath Perth, but this is most unlikely unless the beds dip steeply to the west (indeed, Coleman (1952) states that an easterly dip is possible) or are faulted.

Notes on Species

Globorotalia chapmani Parr

Pl. 1, figs. 1-9.

Globorotalia chapmani Parr, 1938, p. 87, pl. 3, fig. 8, 9.
Globorotalia membranacea (Ehrenberg); Glaessner, 1937b, p. 385, pl. 4, fig. 38; Subbotina, 1953, p. 205, pl. 16, fig. 7-10.
Globorotalia elongata Glaessner; Bolli, 1957, p. 77, pl. 20, fig. 11-13; Loeblich and Tappan, 1957, p. 189, many figs.
Globorotalia pseudomenardii Bolli; Nakkady, 1959, p. 462; pl. 4, fig. 3.
Globorotalia troelseni Loeblich & Tappan; Gohrbandt, 1963, p. 51, pl. 6, fig. 13-15 (synonymy).

Parr's species has been overlooked consistently by recent students of Lower Tertiary faunas, presumably because of the misleading title of his paper. Parr's description of *Globorotalia chapmani* is given in full:

"Test biconvex, oval, the dorsal surface more convex than the ventral, which is umbilicate; periphery lobulated, peripheral margin rounded; chambers comparatively few, not more than five in the last-formed whorl, each much larger than its predecessor; sutures depressed, not limbate, gently recurved on both sides of the test; wall smooth and punctate, with a silvery lustre; aperture an elongate slit with a slight lip, opening at the base of the last-formed chamber into the umbilical depression. Length up to 0.65 mm".

Notes on Morphology.—*Globorotalia chapmani* is characterized by an imperforate marginal band which gives the impression of being a keel, but oriented thin sections show that the wall is not thickened in any way in this region.

The test varies somewhat in plan, from almost equilateral to strongly elongate due to variable increase in chamber size. The chambers of *G. chapmani* vary in inflation and the sharpness of the periphery, but typically they have an equally biconvex arrowhead shape in profile, and the early chambers usually are depressed below the outer whorl. In some individuals this is not so: the inner whorls are raised giving a broadly convex spiral surface. On both sides the sutures are distinctly depressed.

Remarks.—A metatype of *Globorotalia pseudoscitula elongata* Glaessner (collection of M. F. Glaessner) is very similar to juveniles of *Globorotalia pseudomenardii* Bolli. Russian workers (e.g. Shutskaya 1956) no longer distinguish the variety *elongata* formally from *pseudoscitula*. This species is quite distinct from "*Globorotalia elongata*" of recent workers (see also Gohrbandt, *l. c.*).

"*Globorotalia elongata*", as figured by Loeblich and Tappan, Bolli, and others, is quite variable in profile due to variation in compression of chambers and angularity of margin. Specimens from the Salt Mountain Limestone, Alabama, examined through the kindness of Prof. L. D. Toulmin (Tallahassee, Florida) show clearly that this form is *G. chapmani*.

Specimens of *Globigerina compressa* Plummer (Upper Midway, Lockhart, Texas, coll. H. J. Plummer, in collection of M. F. Glaessner) have been examined. They are smaller than *Globorotalia chapmani*. The chambers become distinctly compressed in the adult stage but they are more rounded in profile than in *chapmani*, and the margin lacks the imperforate zone (see also Hofker, Nat. Maandblad, 47:3-4, 1958).

Crespin (1954; Raggatt and Crespin 1955) has recorded *Globorotalia chapmani* from the Upper Eocene of Southern Australia. In the absence of description or figures, it is not known to which species she was referring. *G. chapmani* has not been seen in any of the material at hand from the same formations, and Carter (1958) did not mention its presence in Victoria. Possibly Crespin was referring to *Pseudohastigerina*.

Occurrence.—In several samples; 60 specimens examined.

References

Baker, G. (1953).—The relationship of *Cyclammina*-bearing sediments to the older Tertiary deposits south-east of Princetown, Victoria. *Mem. Nat. Mus. Melb.* 18 : 125-134.

Beckmann, J. P. (1957).—*Chiloguembelina* Loeblich and Tappan and related foraminifera from the Lower Tertiary of Trinidad, B.W.I. *Bull. U.S. Nat. Mus.* 215 : 83-96.

Berggren, W. A. (1964).—The recognition of the *Globorotalia uncinata* Zone (Lower Paleocene) in the Gulf Coast. *Science* (In Press).

Bolli, H. M. (1957).—The genera *Globigerina* and *Globorotalia* in the Paleocene-Lower Eocene Lizard Springs Formation of Trinidad, B.W.I. *Bull. U.S. Nat. Mus.* 215 : 61-82.

Bolli, H. M. and Cita, M. B. (1960).—Upper Cretaceous and Lower Tertiary planktonic foraminifera from the Paderno d'Adda section, northern Italy *Rep. XXI Int. Geol. Congr.* 5 : 150-161.

Bramlette, M. N. and Sullivan, F. R. (1961).—Coccolithophorids and related Nannoplankton of the early Tertiary in California. *Micropaleont.* 7 : 129-188.

Brotzen, F. (1948).—The Swedish Paleocene and its foraminiferal fauna. *Sverig. Geol. Unders.* Afh. 493 : 1-140.

Brotzen, F. and Pozaryska, K. (1957)—The Paleocene in Central Poland. *Acta Geol. Polon.* 7 : 273-277.

———— (1961).—Foraminifères du Paléocène et de l'Éocène inférieur en Pologne septentrionale. Remarques paléogéographiques. *Rev. Micropaléont.* 4 : 155-166.

Carter, A. N. (1958).—Tertiary foraminifera from the Aire District, Victoria. *Bull. Geol. Surv. Vict.* 55 : 1-76.

Churchill, D. M. (1960).—Living and fossil unicellular Algae and Aplanospores. *Nature, Lond.* 186 : 493-494.

Coleman, P. J. (1952).—Foraminiferal investigations in the Perth Basin, Western Australia. *J. Roy. Soc. W. Aust.* 36 : 31-43.

Cookson, I. C. and Eisenack, A. (1961).—Tertiary microplankton from the Rottnest Island bore, Western Australia. *J. Roy. Soc. W. Aust.* 44 : 39-47.

Crespin, I. (1950).—Australian Tertiary microfaunas and their relationships to assemblages elsewhere in the Pacific region. *J. Paleont.* 24 : 421-429.

———— (1954).—Stratigraphy and micropalaeontology of the marine Tertiary rocks between Adelaide and Aldinga, South Australia. *Rep. Bur. Miner. Resour. Aust.* 12 : 1-65.

———— (1956a).—Migration of foraminifera in Tertiary times in Australia. *Ibid.* 25 : 1-15.

———— (1956b).—Changes in ideas of age of certain beds in the Australian Tertiaries. *Ibid.* 25 : 16-25.

———— (1958).—The occurrence of *Hantkenina* in Western Australia. *Micropaleont.* 4 : 317-319.

Cushman, J. A. (1951).—Paleocene foraminifera of the Gulf Coastal region of the United States and adjacent areas. *Prof. Pap. U.S. Geol. Surv.* 232 : 1-75.

Gartner, S. and Hay, W. W. (1962).—Planktonic foraminifera from the type Ilerdian. *Ecl. Geol. Helv.* 55 : 553-572.

Glaessner, M. F. (1937a).—Planktonforaminiferen ausder Kreide und dem Eozän und ihre stratigraphische Bedeutung. *Stud. Micropaleont. Moscow* 1 : 27-52.

———— (1937).—Studien über Foraminiferen aus der Kreide und dem Tertiär des Kaukasus. I. Die Foraminiferen der ältesten Tertiärschichten des Nordwestkaukasus. *Probl. Paleont., Moscow* 2-3 : 349-410.

———— (1956).—Crustacea from the Cretaceous and Eocene of Western Australia. *J. Roy. Soc. W. Aust.* 40 : 33-35.

Glaessner, M. F. and Wade, M. (1959).—Revision of the foraminiferal family Victoriellidae. *Micropaleont.* 5 : 193-212.

Gohrbandt, K. (1963).—Zur Gliederung des Paläogen im Helvetikum nördlich Salzburg nach planktonischen Foraminiferen. *Mitt. Geol. Ges. Wien* 56 : 1-116.

Hay, W. W. (1960).—The Cretaceous-Tertiary boundary in the Tampico Embayment, Mexico. *Rep. XXI Int. Geol. Congr.* 5 : 70-77.

Hillebrandt, A. von (1962).—Das Paleozän und seine Foraminiferenfauna im Becken von Reichenhall und Salzburg. *Ab. Bayer. Akad. Wiss. Math.—Nat. Kl. (N.F.)* 108 : 1-182.

Loeblich, A. R. and Tappan, H. (1957).—Planktonic Foraminifera of Paleocene and early Eocene age from the Gulf and Atlantic Coastal Plains. *Bull. U.S. Nat. Mus.* 215 : 173-198.

Ludbrook, N. H. (1963).—Correlation of the Tertiary rocks of South Australia. *Trans. Roy. Soc. S. Aust.* 87 : 5-15.

McGowran, B. (1962).—Foraminifera and biostratigraphy of the Australian Maastrichtian and Paleocene. *Unpubl. Thesis Univ. Adelaide: 1-391.*

McWhae, J. R. H., Playford, P. E., Lindner, A. W., Glenister, B. F. and Balme, B. E. (1958).—The stratigraphy of Western Australia. *J. Geol. Soc. Aust.* 4 (2) : 1-161.

Nakkady, S. E. (1959).—Biostratigraphy of the Um Elghanayem section, Egypt. *Micropaleont.* 5 : 453-472.

Olsson, R. K. (1960).—Foraminifera of latest Cretaceous and earliest Tertiary age in the New Jersey coastal plain. *J. Paleont.* 34 : 1-58.

Parr, W. J. (1938).—Upper Eocene foraminifera from deep borings in King's Park, Perth, Western Australia. *J. Roy. Soc. W. Aust.* 24 : 69-101.

———— (1947).—An Australian record of the foraminiferal genus *Hantkenina*. *Proc. Roy. Soc. Vict.* (n.s.) 58 : 45-47.

Plummer, H. J. (1927).—Foraminifera of the Midway Formation in Texas. *Bull. Univ. Tex. Bur. Econ. Geol. Tech.* 2644 : 1-206.

Pozaryski, W. and Pozaryska, K. (1960).—On the Danian and Lower Paleocene sediments in Poland. *Rep. XXI Int. Geol. Congr.* 5 : 170-180.

Raggatt, H. G. and Crespin, I. (1955).—Stratigraphy of Tertiary rocks between Torquay and Eastern Views, Victoria. *Proc. Roy. Soc. Vict.* (n.s.) 67 : 75-142.

Said, R. and Kerdany, M. T. (1961).—The geology and micropaleontology of the Farafra Oasis, Egypt. *Micropaleont.* 7 : 317-336.

Shutskaya, E. K. (1956).—Stratigraphy of the lower horizons of the Paleogene of the central pre-Caucasus, based on foraminifera). *Trav. Inst. Sci. géol. Akad. Nauk S.S.S.R.* 164 : 1-119 (in Russian).

Subbotina, N. N. (1953).—(Fossil foraminifera of the U.S.S.R.: Globigerinidae, Hantkeninidae and Globorotaliidae). *Vses. Neft. Nauk-Issl. Geol. Trudy* 76 : 3-29 (in Russian).